Continuation of NASA Grant No. NAGW-1560
(December 16, 1996 to December 15, 1997)

ClO Measurements and Analysis in the Network for the Detection of Stratospheric Change

Principal Investigator: Professor Philip Solomon

The past year has been very productive, particularly at the Scott base, Antarctica site.

I. Progress Report (prior to October 1996)

I.1 Goals

The goals of this project remain the same:

1. To monitor the ClO content of the atmosphere on a long-term basis using our instruments at Mauna Kea, Hawaii and Scott Base, Antarctica as part of the Network for the Detection of Stratospheric Change (NDSC). Data acquisition is monitored and controlled from SUNY at Stony Brook. The data are downloaded daily to Stony Brook where they are stored and processed.
2. To obtain altitude profiles of ClO from 16 to 47 km to be used as part of the complete picture of the stratosphere.
3. Comparison of ground-based with space-based measurements of ClO. The latter include measurements made by Upper Atmosphere Research Satellite (UARS) and any future space-based missions. These ground-based instruments will also be the major source of complete altitude profiles of ClO if space-based instruments cease operations.
4. Inter-comparisons of the three millimeter-wave ClO instruments built by Millitech to check for consistent calibration. Two of these have already been compared in Hawaii with excellent results. The French instrument has been brought to Hawaii (July 1996) for inter-comparison.

One of the ClO Millimeter Wave Instruments (A) was returned to Mauna Kea, Hawaii in November 1995 after being repaired at Millitech. It was installed successfully and collected data continuously till August 1996 (see Figure 1). Due to a power failure, the instrument started behaving erratically and was shipped to Millitech for repairs. The instrument has been repaired and is due to be back in Mauna Kea by November 1996.

Instrument B was shipped to New Zealand in December, 1996 and was installed successfully at Scott Base, Antarctica (latitude 78° S) in January, 1996. Brian Conner (NIWA) and Jim Barrett (Stony Brook) stayed in Scott Base for a month for the installation and testing purposes, and the instrument has been collecting data continuously since.

I.2 Summary of Mauna Kea Operations (instrument A)

- High quality data obtained on 1/3 to 1/2 of the days.
- Excellent data obtained on approximately 1/4 of the days (variable with season).
- Downtime due to equipment problems is about 20%.

I.3 Summary of Scott Base Operations (instrument B)

- The instrument was shipped to Antarctica in mid-January 1996 and it was installed and tested successfully by mid-February 1996. This was done in collaboration with NIWA.
- The Stony Brook-NIWA collaboration is successful.
- High quality data obtained only on 1/4 of the days due to bad weather and blowing snow.
- The instrument is working reasonably well, although the baseline problem still persists. However, the data during the important August- October period are quite good due to successful day-night subtraction.
- It is probably desirable in the near future to upgrade this instrument but this will probably require additional funds not requested in this proposal. The most important science is being obtained with the present instrument.

I.4 Summary of Mauna Kea, Hawaii Results

- There has been a 40% increase in middle (30 to 45 km) stratospheric ClO from the period 1983 to 1995. This is in good agreement with that expected from models of the production of CFCs and transfer into the stratosphere.
- There is a good correlation between our low altitude ClO and the presence of Mt. Pinatubo aerosols. This demonstrates the operation of heterogeneous chemistry in the Mt. Pinatubo aerosol cloud. The ClO in the lower stratosphere (20 to 27) km is higher in 1992 than late 1993–1994 and 1994 is slightly higher than 1995 (see Figure 2). The Mt. Pinatubo particles were gone by January 1995 but were still present in the first 6 months of 1994, although reduced by a factor of 2 from 1992.
- The middle stratospheric ClO altitude profile is in good agreement with models.

- The diurnal altitude profiles are in general agreement with models but differ in details. (See Figure 3)
- There is good agreement with UARS latitude averaged profiles to within the errors. The UARS mid-stratospheric profiles have larger errors.

I.5 Summary of Scott Base, Antarctica Results

- Data from March to August 1, 1996 show the presence of middle stratospheric ClO with a day – night variation as expected.
- The ClO altitude profile shows a rapid and spectacular change between mid-August 1996 and September 12. The peak mixing ratio at 20 km rises from less than 0.1 ppbv to 1.9 ppbv. The region of active chlorine chemistry extends from about 17 to 24 km. (See Figure 4.) **This is the first time the complete ClO altitude profile has been tracked from before the onset of the ozone hole until its peak.**

II. Work Plan for 1997

We intend to keep both the Mauna Kea and Scott Base instruments operating full time for the entire year. The instrument currently at Scott Base will remain in place unless there is an unexpected deterioration.

All of the data from both instruments as well as the inter-comparison with the French instrument will be analyzed at Stony Brook.

Data will be deposited with the NDSC database.

The inter-comparison with the French instrument will take place during November, 1996 – January 1997, at the Mauna Kea site. Following this the French instrument will resume operation in Europe.

The successful results from both Mauna Kea and Scott Base will be written up for publication.

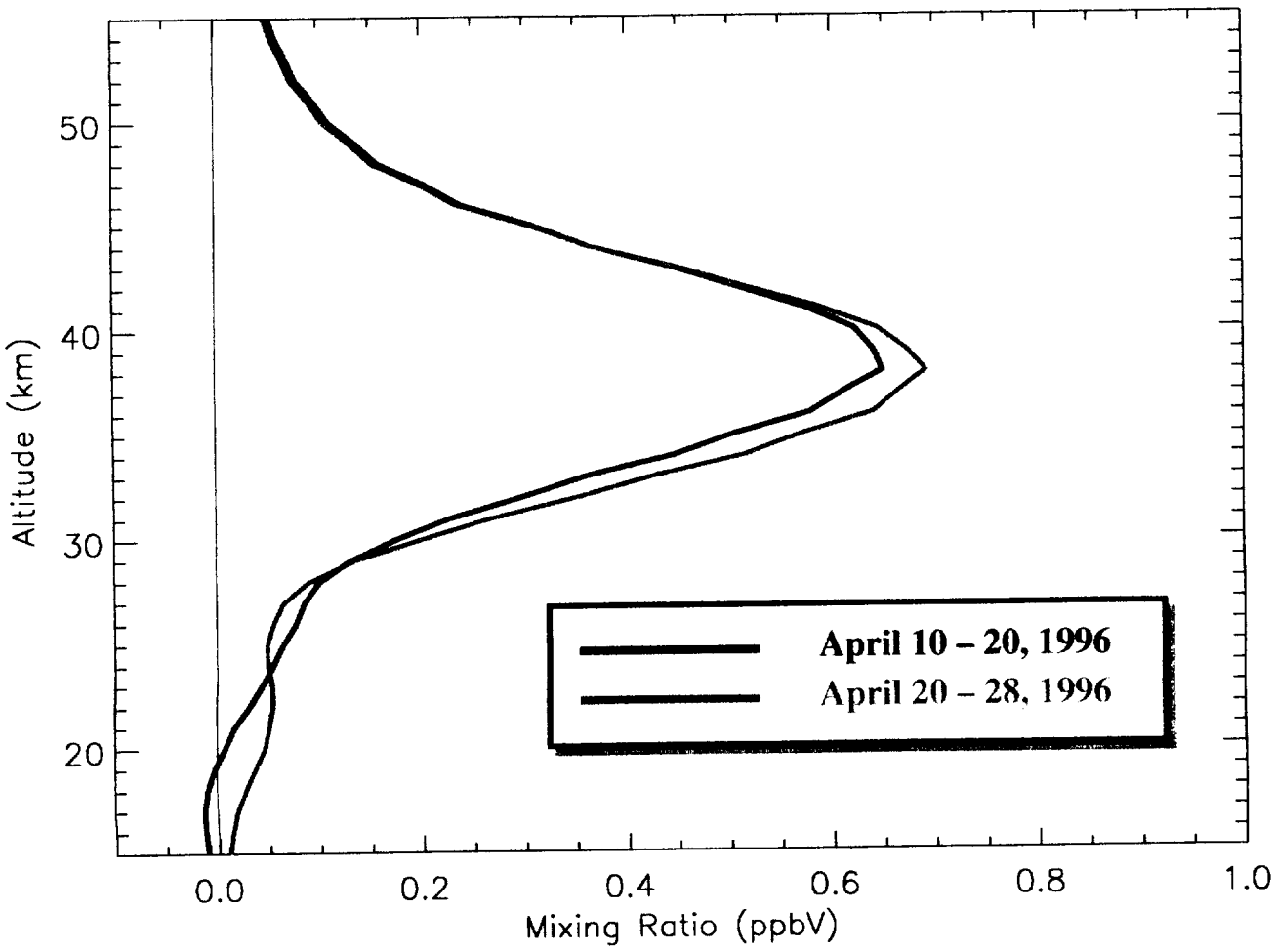

Figure 1. Sample altitude profiles from Mauna Kea, Hawaii using Rodgers optimal estimation method. Each altitude profile is the average of almost one week of observations.

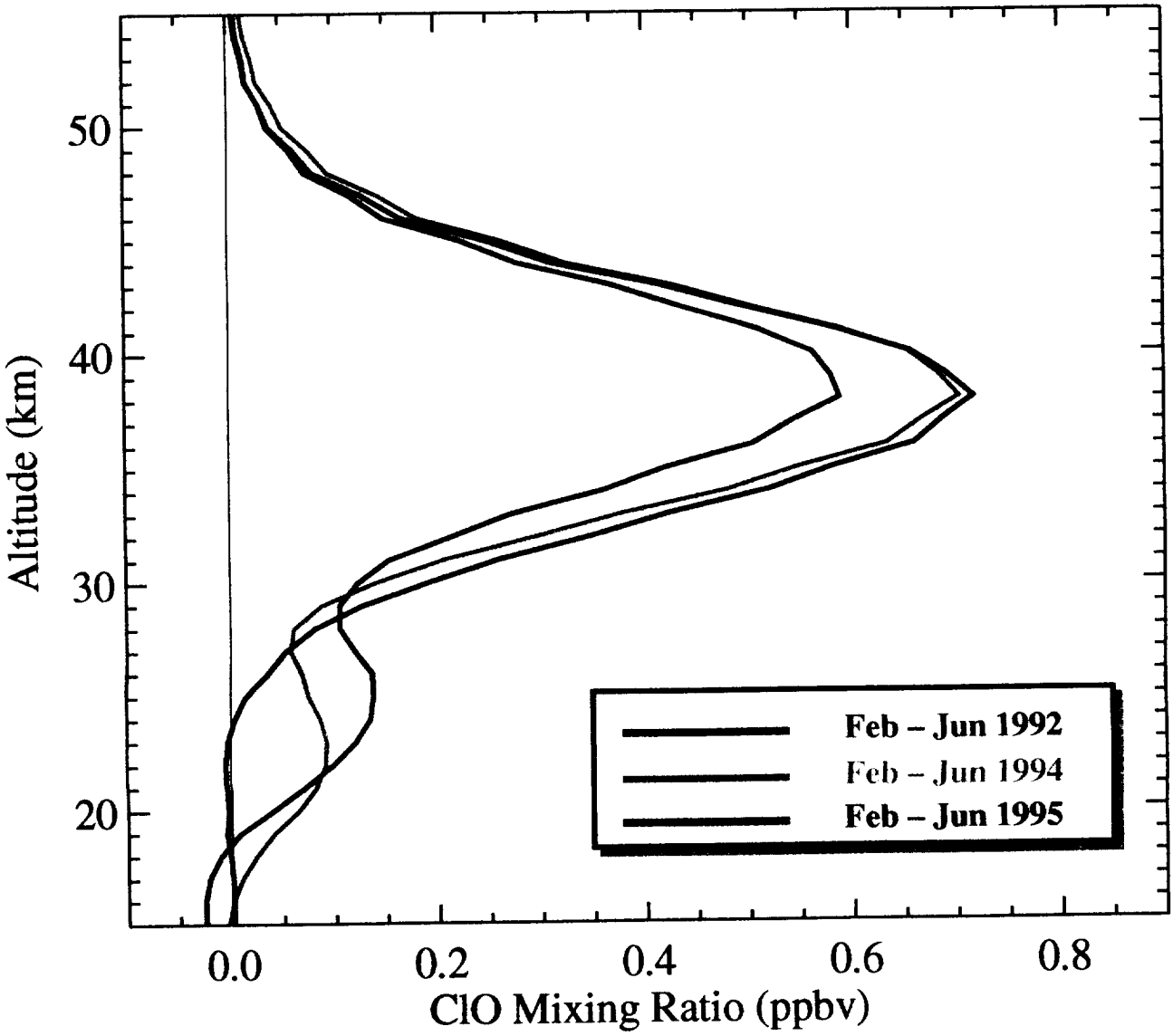

Figure 2. ClO altitude profile during spring 1992, 1994 and 1995 showing evidence for heterogeneous chemistry in the lower stratosphere. The ClO feature between 22 and 28 km is associated with Mt. Pinatubo aerosols which peaked in early 1992 and disappeared by early 1995.

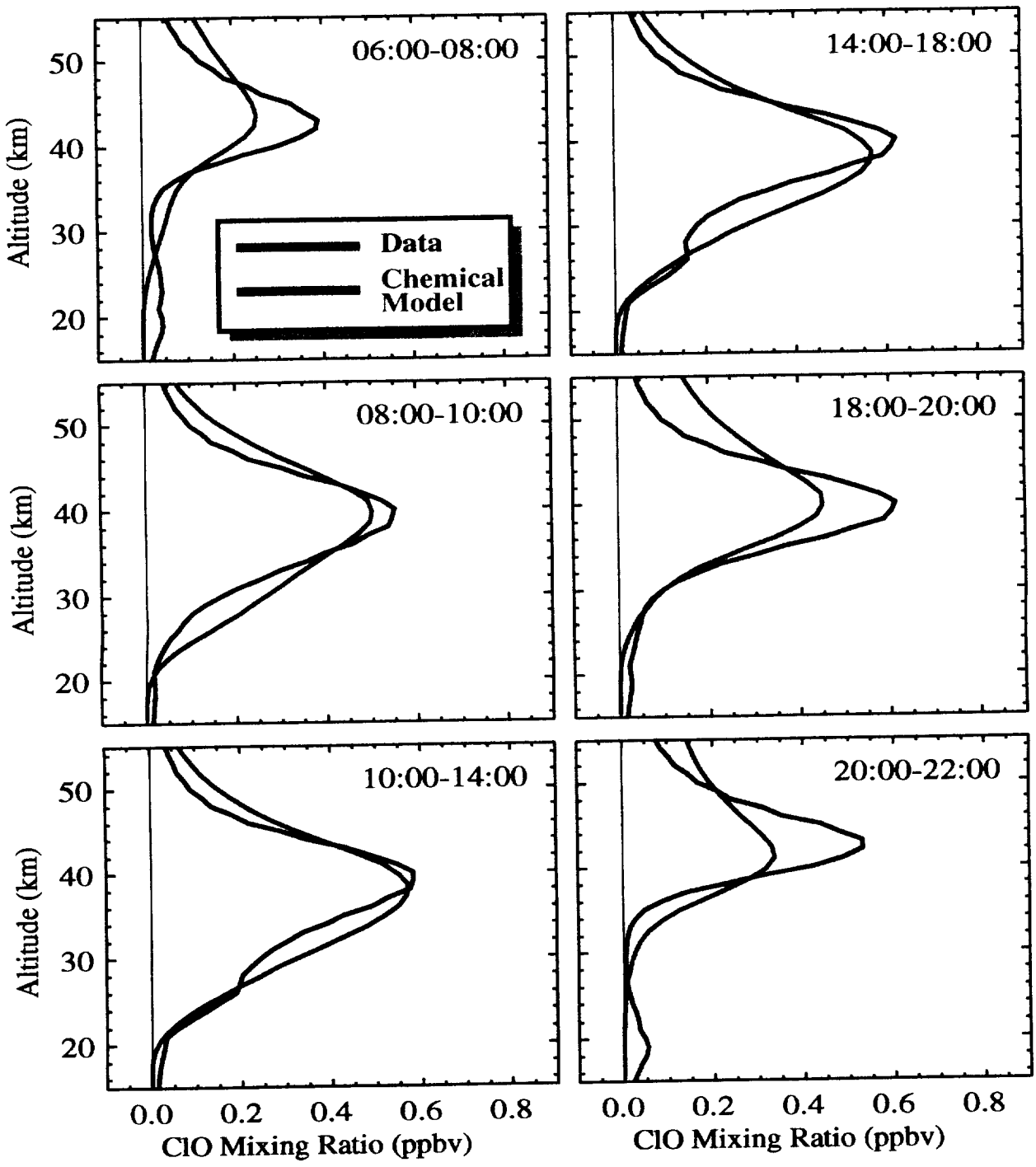

Figure 3. Comparison of diurnal altitude profiles with chemical models for Mauna Kea, Hawaii.

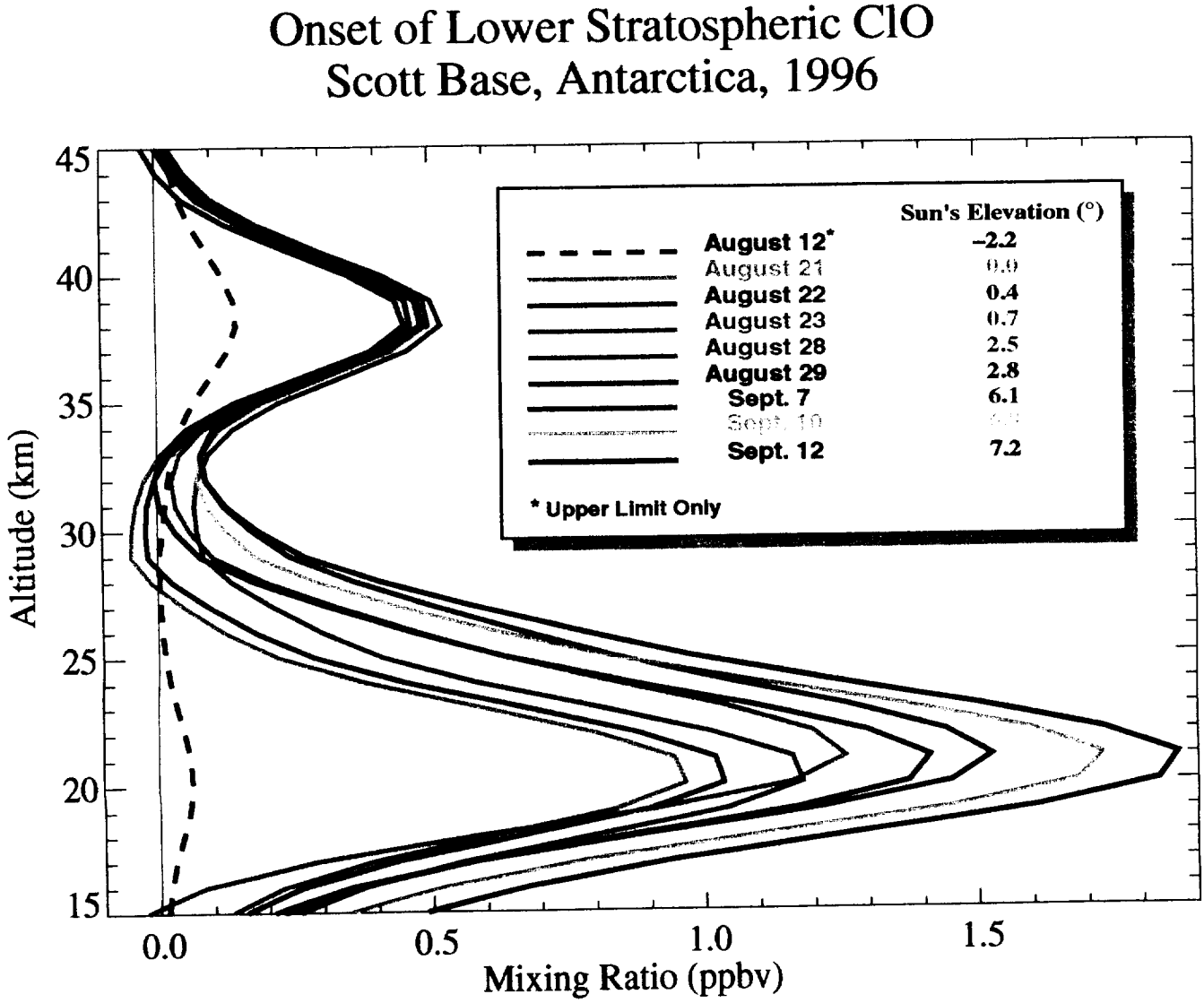

Figure 4. ClO altitude profiles obtained at Scott Base, Antarctica between August 12, 1996 and September 12, 1996. The rise of the peak mixing ratio at 20 km from less than 0.1 ppbv to 1.9 ppbv is a clear indication of the onset of the Ozone hole.